

Flight Operations Segment (FOS) Operations Report Study for the ECS Project

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Abbreviations and Acronyms

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1. Introduction

1.1 Purpose

This study was undertaken to identify potential ways to improve Flight Operations Team (FOT) efficiency and to possibly reduce life cycle costs. To accomplish this goal the following topics are addressed:

- 1) the typical tasks performed within a control center are delineated. The paper discussed how the ECS approaches to accomplishing the tasks have improved over old approaches, and identifies areas for further study,
- 2) the EOC architecture's proposed ability to support multi-mission staffing vs. mission-based staffing,
- 3) the pro's and con's of multi-mission staffing are compared and contrasted with mission-based staffing, and
- 4) key areas are identified where additional technology insertion or operational concept evolution may decrease life-cycle operational costs.

The study focuses on operations of the AM-1 spacecraft, but also considers operations concerns and options in a multi-mission environment. Any and all recommendations are based on our current understanding of the FOS architecture and instrument manifest. Our knowledge of future spacecraft and bus architecture is limited. Further knowledge in these areas will enable us to refine our recommendations.

1.2 Organization

This paper is organized as follows:

Section 1 Introduction

Section 2 Background - Discusses the challenges of operations and the typical tasks performed in a control center.

Section 3 Operational Concepts - Discusses operational string concept, presents scenarios for multi-mission staffing and presents issues, concerns and options for multi-mission staffing.

Section 4 Findings - Describes opportunities for reduced life-cycle costs.

Section 5 Operations Trade Study Process - Discusses the ongoing process of updating this study.

Appendix A EOC Staff Positions - includes summary job descriptions.

Appendix Abbreviations and Acronyms

1.3 Review and Approval

This document is an informal contract deliverable approved at the Office Manager level. It does not require formal Government review or approval; however, it is submitted with the expectation that review and comments will be forthcoming.

The ideas expressed in this White Paper are valid for June 1994; the concepts presented here are expected to migrate into the following formal CDRL deliveries:

Table 1-1. White Paper to CDRL Migration

White Paper Section	CDRL DID/Document Number
3 - Operational Concepts	604/OP1 - ECS Operations Concept Document
4 - Findings	304/DV1 - Segment/Element Requirements Specification 305/DV2 - Element Design Specifications
Appendix A - Staff Positions	604/OP1 -ECS Operations Concept Document

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2. Background

2.1 The Operations Challenge

The purpose of this document is to investigate ways that the FOS development process can lead to increased FOT efficiency and reduce life-cycle costs. The operations dilemma is that the operational staffing profiles continue to be oriented around traditional operational concepts and mature control center architectures. The challenge then becomes not only avoiding the "same old approach" to control center staffing (e.g., dedicated teams for each spacecraft), but to make the correct decisions on staffing levels, staffing profiles and apportionment of responsibilities within the FOT. In general terms, the FOT staffing positions, responsibilities, and tasks have not varied much in the past decade. With evolving technological advances in hardware and software, the FOT profile (i.e., the position descriptions and responsibilities) can be modified. The ECS proposal did not assume this "same old approach" mentality. What was bid was a highly modernized EOC system.

In particular, this paper will address how the FOT performance can be enhanced by both recent technological advances as well as potential future technological advances. The proposed architecture plans are studied to determine if it can support different staffing scenarios. Operational concepts are reviewed. And areas are identified where additional technology insertion will provide the best payback in terms of reduced long term operational costs.

2.2 EOC Functional Inventory

2.2.1 High Level Functional Inventory

Table 2-1 contains a high level inventory of functions carried out within the ECS Operations Center (EOC) to support the AM-1 mission. Details of the activities are contained in table 2-2, FOT Functional Inventory. These are living lists to be updated as operational concepts evolve, technology evolves, and the FOS architecture becomes better defined throughout the development process. This inventory helps in understanding the distribution of responsibilities among FOT staff positions, and in identifying planned technology insertion (ECS Approach) and opportunities for future technology insertion (future study). EOC position descriptions are summarized in Appendix A.

Table 2-1 shows the activities that occur within the EOC rolled up into general activity categories. The specific tasks associated with this general activity category can be found in Table 2-2. For each category the nominal effort, repetitive period, operator priority, old approach, ECS approach and further study are listed. The Effort column is a generalization of the amount of time to be spent within the control center to accomplish the tasks associated with that activity. The Periodic column gives an idea of how often these tasks are performed. The Operator Priority column is an indication of the criticality of the activities to the safe operation of the EOC. The Old Approach column lists some of the typical ways that the activities were

Table 2-1. High Level Functional Inventory

Activity	Effort	Periodic	Operator Priority	Old Approach	ECS Approach	Study
Real-time TLM analysis	20 min/orbit	Every contact	High	TDRSS supports concurrency , Multiple spacecraft Manually intensive	MIS, Logical strings	MMS, Enhanced DDS, Pass automation, Resource allocation tool
Real-time command	20 min/orbit	Every contact	Very high	Dynamic, Must be correct Paper requests Manually intensive	Logical strings	MMS , Pass automation
Post-pass analysis	40 min/dump	Every dump	High	Large data volume Plot all dumps Lots of plots Must correlate data Manual analysis No intelligence in plot system	Selective plot, DSS, On-screen analysis, On-line tools to correlate data, Reduced effort, Intelligent plotting	Enhanced DSS, MMS
Initial scheduling	1 day/week 6-8 hours	Every week	Moderate	Manual inputs Paper requests Manual conflict resolution	Integrated Tools	MMS
Final scheduling	Every day 8 hours/day	Every day	Moderate	Manual schedule analysis Manual inputs Paper requests Manual conflict resolution	Integrated Tools	MMS
Command & table load generation	Every day 8 hours/day	Every day	Very high	Must be correct Must be on time File I/O intensive Computationally intensive Manually intensive	Seamlessly Integrated P&S->CMS->CMD	Additional automation, MMS
Subsystem Performance Analysis	40 min/dump	Every dump	High	Large data volume Plot all dumps Lots of plots Must correlate data Manual analysis No intelligence in plot system	Selective plot, DSS, On-line tools to correlate data, Reduced effort, Intelligent plotting	Enhanced DSS, MMS, Additional automation

Key:

CMD - Commanding System
 CMS - Command Management System
 DSS - Decision Support System
 MIS - Multi-Instrument Staffing
 MMS - Multi-Mission Staffing
 P&S- Planning and Scheduling

accomplished in previous control centers. The ECS Approach column specifies the approaches that are different to the old approach which are currently planned for the EOC. The Further Study column is a high level indication of areas of study that could result in a large payback in terms of reduced life-cycle costs.

The columns titled "old approach", "ECS approach" and "future study" can be thought of as the past, present and future of control center operations. The transition from past to present has brought us the ability to automate many repetitive, time consuming, manual tasks. That in itself provides opportunities for efficiencies within the FOT, freeing the staff from manual tasks and allowing them to do more in-depth engineering, analysis and planning. This transition to the ECS approach shows that we have come far in placing ourselves into the 1990's in control center development. Further advancements in the state of the art in control center development will be tracked and incorporated into the EOC. The future study column highlights opportunities to transition to the next generation of control centers. These areas are discussed throughout the paper and findings are presented in section 5.

2.2.2 FOT Functional Inventory

Table 2-2 shows a more detailed breakout of the FOT activities. Each activity from table 2-1 is broken up into multiple functions. For each function the following information is listed: mechanism, how often, how long, human interaction, criticality of correctness and future study. The mechanism, how often and how long columns are self-explanatory. The human interaction column is a rough indication of the amount of operator concentration and involvement that is required during the "how long" time period to accomplish the task. The criticality of correctness is an indication of task's importance to the safe operation of the spacecraft. By examining the "how often", "how long", "human interaction" and "criticality of correctness" columns together, a determination can be made toward which functions are candidates for further study. These candidates provide the greatest opportunities for increased FOT efficiencies. The "further study" column identifies options that are discussed throughout the rest of this paper. For example, the function "review timelines for upcoming events" is done each contact, but only for a 2 minute period, requires low human interaction, and has a low criticality factor. This is not a good candidate for further study or further automation. The function "monitor clock drifts" only takes 20 seconds per contact. Additional automation could be added to perform this function, but the cost of automating the function would be greater than the payback of increased FOT efficiency. Conversely, any automation which could decrease the FOT loading to "monitor spacecraft subsystem health and safety" or "monitor instrument health and safety" (both of which have high human interaction, high criticality, and occur 10 minutes for each contact) could provide a high FOT efficiency payback. Future study candidates for those functions are enhanced decision support system (DSS) capabilities and multi-mission staffing (MMS).

Table 2-2. FOT Functional Inventory (1 of 3)

Activity	Function	Mechanism	How Often	How Long	Human Inter-action	Criticality of Correct-ness	Future Study
Real Time TLM Analysis	Monitor Spacecraft Subsystem Health and Safety	Display Pages, Limits/Alarms, Quick Analysis	Every Contact	10 Min	High	High	Enhanced DSS, MMS
	Monitor Instrument Health and Safety	Display Pages, Limits/Alarms, Quick Analysis	Every Contact	10 Min	High	High	Enhanced DSS, MMS
	Monitor TDRSS Ground Station Performance Data	Display Pages, Graphs, Limits/Alarms, STOL Tests	Every Contact	10 Min	Medium	Moderate	Enhanced DSS, MMS
	Monitor Clock Drifts	Display Pages	Every Contact	20 Seconds	Medium	High	
	Monitor S/C Recorder Playback Quality	Display of EDOS Quality Information	Every Recorder Playback	10 Min	Medium	Moderate	Enhanced DSS, MMS
	Monitor Ground System Performance	Display Pages	Every Contact	5 Min	Medium	Moderate	Enhanced DSS
	Shift Briefings/Debriefings	Verbal	Each Shift Change	15 Min	High	Moderate	
	Lead Real-Time Anomaly Resolution		As Required	As Required	High	High	Resource Allocation Tool
	Troubleshoot Ground System Anomalies		As Required	As Required	High	Moderate	
	Review S/C Activity Log	Diagnostic Data and Trend System Utilities	Every Contact	10 Min	Low	High	Enhanced DSS
Real Time CMD	Monitor Ground Script Execution	Command Execution Page	Each Contact	20 Min	Medium	High	Pass Automation
	Control Ground Script Execution	Command Execution Page, Real-Time System	Each Contact	10 Min	Medium	High	Pass Automation, DSS
	Verify Command Load Transmission	CMS Utilities and Memory Maps	Evals	10 Min/Day	High	High	Pass Automation
	Monitor/Verify Command Activity	Command Execution Page and TLM Service	Each Contact	1 - 10 Min	High	High	Pass Automation
	Transmit Unscheduled Commands and Loads	Commanding Service, Command Requests	Infrequently (Once a Shift)	5 Min	High	High	
	Modify Ground Script	CMS	Infrequently (Once a Shift)	5 Min Per Change	Medium	Moderate/High	
	Review Timelines For Upcoming TDRSS Events	CMS, P&S	Each Contact	2 Min	Low	Low	
	S/C Recorder Mgmt	SSR Playback Manager	Each Contact	Duration of Contact	High	Low	Pass Automation
	Pre-Pass Setup	Resource Manager, Automated	Prior to Each Contact	5 Min	Low	High	
	Approve Real-Time Command Uplinks	Commanding Screen	Prior to Each Uplink	1 Min	High	High	
	Coordinate Contact Schedule Changes	P&S, CMS	Infrequently (Twice a Month)	10 - 20 Min	Medium	High	
	Coordinate Aster Instrument Command Uplink	Commanding Interface, Phone, Email, Resource Manager	Very Infrequently	5 Min	Medium	High	XVideo

Table 2-2. FOT Functional Inventory (2 of 3)

Activity	Function	Mechanism	How Often	How Long	Human Inter-action	Criticality of Correct-ness	Future Study
Post Pass Analysis	Evaluator Support of Off-Line Analysis	Off-Line Tools	Off Shift Support, Several Times a Week	1 - 10 Min	Medium	Moderate	Enhanced DSS, MMS, Selective Analysis Of Back-Orbit Data
	Support Testing of Database, S/W Deliveries	Real-Time System	Each Delivery (Once Every 3 Months)	4 Hours	Low	Moderate	
	Review Limits in New Database Deliveries	Database Browser	Every Database Delivery	30 Min	High	Moderate	
	TLM Archive	Data Management System, Automated	Each Contact	10 Min per Contact	Low	Low	
	Manage Clock Updates	Displays	Once a Week	5 Min	Low	High	
Initial Scheduling	Perform Routine Scheduling of Science Instruments	P&S Tools	Every Day	8 Hours	High	Moderate	MMS
	Routine Scheduling of Space Network Resources	P&S Tools	Every Day	Full Time	High	Moderate	MMS
	Routine Scheduling of Spacecraft Resources	P&S Tools	Every Day	Full Time	High	Moderate	MMS
	Activity Definition Maintenance	P&S Tools	Infrequently (Once A Month)	5 Min	Medium	Low	MMS
	Aster Instrument Scheduling	P&S Tools	Late Shift, Every Day	Entire Shift	High	Moderate	MMS
Final Scheduling	Support Scheduling Conflict Resolutions	P&S Tools	Infrequently (Once a Week)	5 Min - 4 Hours	High	High	MMS
	IST Request Support	P&S Tools	Per Request	5 - 15 Min	Medium	Low	MMS
	Support Aster Schedule Changes (TOOs And Late Changes)	P&S Tools	As Required	2 Hours	High	High	
	Support NCC & TDRSS Schedule Changes	P&S Tools	Infrequently (Twice a Month)	2 Hours	High	High	
Command and Table Load Generation	Generate Detailed Activity Schedule	P&S Tools	Once per Day	10 Min	Low	Moderate	Additional Automation, MMS
	Generate Absolute Time Command Loads and Ground Scripts	CMS Tools	1 - 4 Loads per Day	10 Min	Low	High	Additional Automation, MMS
	Support SN Schedule Changes and Corrective ATC Loads	CMS Tools	Every SN Change (Twice a Month)	2 - 4 Hours	High	High	Additional Automation, MMS
	Ephemeris Generations And Validation	CMS Tools	Once per Day per S/C	10 Min Per S/C	Low	High	Additional Automation, MMS
	Generations of Spacecraft Command Loads	CMS Tools	As Required	10 Min To 4 Hours	Medium	High	Additional Automation, MMS
Subsystem Performance Analysis	Develop Command Procedures	Procedure Builder, CMS Validation Tools	Infrequently (Once a Month)	40 Min	High	High	

Table 2-2. FOT Functional Inventory (3 of 3)

Activity	Function	Mechanism	How Often	How Long	Human Inter-action	Criticality of Correct-ness	Future Study
	Submit Database Modifications	Database Tools	Infrequently (Twice a Month)	20 Min	Low	High	
	Validate Database Contents	Database Tools	Each Db Delivery	2 - 4 Hours	Medium	High	
	Initiate S/C Configuration Changes	Procedure Builder, RTS, CMS	As Required	As Required	Medium	High	Enhanced DSS
	Support Ground System Tests	EOC	Prior to Each Mission Launch	12 Hours a Day Pre-Launch	High	High	
	Review Telemetry /Trend Plots	Analysis Software	Each Day	6 Hours Per Day	High	High	Enhanced DSS, MMS, Selective Analysis Of Back-Orbit Data
	Generate Subsystem Reports	Report Generation Software	Each Week	3 Hours Per S/C	High	Low/Moderate	Additional Automation
	Anomaly Analysis	Analysis Software	As Required	12 Hours A Day During Anomaly	High	High	Additional Automation, Enhanced DSS
	Analyze FDF Products	Analysis Software	Each Day	2 Hours Per Day	Medium	Moderate	
	Review Spacecraft HW/SW Configuration Changes	History Logs	Each Week	10 Min	Low	High	
	Interface with Vehicle Contractor for Subsystem Operations Issues	Phone, Email, Fax	As Required	As Required	High	Moderate	Electronic Interface

3. Operational Concepts

3.1 Architectural Flexibility

A key FOS architecture requirement is to ensure that it is designed to be evolvable to support up to seven spacecraft simultaneously in varying states of development, testing, and operations. The challenge in fulfilling this requirement is that the system will evolve over a period of years before the full complement of seven spacecraft will be in the system. Thus, a framework is needed to support this system.

The primary objective of the FOS architecture is to provide a system that can be used operationally for multiple spacecraft and instruments in an efficient, streamlined manner. The FOS architecture will include two key characteristics in its framework: distributed processing and integrated operations. The set of FOS computers will distribute the disparate operational tasks (e.g., planning and scheduling, real-time monitoring, and off-line analysis) between workstations and servers to balance the performance load, while integrating the operations through logical strings.

3.1.1 Distributed Processing

Distribution of the FOS architecture is performed in several ways. A goal is to organize and partition the work into the operational phases -- e.g., scheduling, real-time contacts (pre-pass, pass, and post-pass), and off-line analysis. The workstations facilitate this structured partitioning by enabling any of these operational phases to be performed on any workstation. The operator can select the operations phase or task to perform, and the application software will present a user interface that focuses on the operations task requested (e.g., scheduling). This concept enables the operations staff flexibility in performing multiple tasks efficiently. For example, a scheduler can build a detailed activity schedule (a Scheduling task) and a ground script (Command Management task) in succession from the same workstation.

Distribution also means distributing the computer processing within the network. This enables compute-intensive operations to be performed on specialized server machines without interfering with time-critical operations. The operator can still initiate the operation from a workstation. However, the fact that the task is being performed on another computer in the network is transparent to the FOT. This concept is significant when adding additional spacecraft and instruments into the EOC's domain since the infrastructure is in place to support additional computing resources in the network without affecting current operations.

3.1.2 Integrated Operations

Integrated operations is accomplished through the use of logical strings within the FOS. A logical string means that the telemetry and command processing for a single spacecraft is logically connected via the FOS network to the real-time processing of a spacecraft pass. Specifically, many operators can monitor the housekeeping telemetry, the execution of the

ground script, and the verification of commands associated with the AM-1 spacecraft by connecting to the logical string for AM-1 from their individual workstation. The operator is able to focus on the operations, identification of anomalies, alarm messages, and event messages associated with that spacecraft's real-time contact -- information associated with other concurrent contacts are filtered from the operator's display. The logical string concept can be extended easily to support the addition of future spacecraft and instruments into the FOS since the infrastructure to support them will exist from the beginning.

The logical string concept can be refined to enable the FOT to support multiple spacecraft and instruments in the future more efficiently. Two key characteristics that can be taken advantage of include common spacecraft buses and similar instruments on different spacecraft. In both cases, the logical string characteristic of focusing data for the operator's position is critical. In the case where common buses are being monitored, an operator could request to monitor multiple spacecraft by connecting to multiple logical strings. The operator, focusing on the Power subsystem for example, would be able to view Power display data on the workstation for several spacecraft. Similarly, an operator could request to monitor multiple instruments by connecting to multiple logical strings. The operator, focusing on the CERES instrument, would be able to view CERES housekeeping telemetry on the workstation for several spacecraft. Note that an operational constraint that would remain is that only one operator would be able to command a single spacecraft at any given time.

The benefits to be gained in operational efficiency and quality improvements in flight operations are potentially large due to the evolutionary nature of the EOS mission. The dual concepts of distribution and integration provide a framework to develop the system and enhance operations.

3.2 Mission-Based Model of Operations

Section 7 of the ECS Operations Concept Document for the ECS Project (193-604-OP1-001) August 1993, contains a representative discussion of the flight operations operational concepts and functional requirements. Scenarios are described for: planning and scheduling, command management, real-time, and spacecraft analysis. Updated scenarios that reflect the results of the EOC/ICC Trade Study, this trade study, and the evolved operational concepts will be presented in the next version of the Operations Concept document.

The scenarios in the current version of the Operations Concept document are mostly presented as mission-based scenarios, meaning that the positions and functions are described as operating one spacecraft, or one subsystem of one spacecraft, or one instrument on one spacecraft. Each member of the Flight Operations Team (FOT) would be assigned and have responsibilities for one and only one spacecraft. In the presentation of the scenarios there are few discussions that involve staff working on multiple spacecraft, subsystems or instruments.

3.3 Multi-Mission Model of Operations

The following four sections (sections 3.3.x) take the FOS scenarios from the operations concept document and expand them into multi-mission based scenarios. These scenarios are examples of how a staff in the EOC might respond to situations if they had multiple spacecraft, subsystem or

instrument responsibilities. These discussions are included to show different staffing possibilities and to demonstrate the flexibility of and capability of the architecture to support multi-mission staffing. These scenarios highlight "further study" areas from table 2-1.

3.3.1 Multi-Mission Planning and Scheduling Scenario

Planning and Scheduling (P&S) is broken into three primary components: long-term planning, initial scheduling and final scheduling. (Note: initial and final scheduling is analogous to the NCC terms forecast and active scheduling.)

3.3.1.1 Long-Term Planning

The operational concept for instrument schedulers has always been that one scheduler will support one or more instruments, depending on the complexity of the instruments. Long-term planning involves the development of the Long Term Science Plan (LTSP) and the Long Term Instrument Plan (LTIP), the development of the long-term spacecraft operations plan, and the creation of the BAPs. The LTIP and LTSP are developed outside of the FOT. The BAPs are produced by the scheduler for each non-complex instrument. Simple instruments will rarely deviate from their BAP, and their scheduling process will often be complete at this stage. The mission-based scenario has a scheduler, the project scientist, and FOT engineers producing the long term spacecraft operations plan. In a multi-mission environment the schedulers and engineers could have responsibility across spacecraft. For example, a power engineer may have responsibility for two spacecrafts' power subsystems and therefore have input to two long term spacecraft operations plans.

3.3.1.2 Initial Scheduling

PI/TLs (Principle Investigator and/or Team Leader), with help from the schedulers at the EOC, attempt to predict their instruments' resource requirements so that the EOC can establish TDRSS contact times. For non-complex instruments the BAPs are reviewed by the PI/TL. If necessary, instrument resource deviation lists are created by the instrument scheduler and reviewed by the PI/TL. For complex instruments, the instrument scheduler develops an instrument resource profile from information from the following sources: Data Acquisition Requests (DARs), science team collection requests, instrument maintenance activities and instrument calibration. For both non-complex and complex instruments, the FOT scheduler has a significant role. However, this role can be carried out by knowledgeable schedulers, and one scheduler can support many instrument teams in this activity, including instrument teams from different spacecraft. The extent that a scheduler can support multiple instruments depends upon the complexity of the instruments, the volatility of the instruments' schedules, and the efficiency of the P&S tools.

Like instruments, spacecraft subsystems also require certain resources during operations. The off-line engineers perform analysis on the resource needs, and along with the schedulers develop the spacecraft subsystem resource profiles. Off-line engineers are specialists in their domains, and as such could perform this function for several spacecraft, depending on the subsystem complexity.

With the resource profiles for the instruments and spacecraft subsystems, the scheduler integrates them together to determine the overall spacecraft and instrument resource requirements for the target week. Based on these needs, the scheduler formulates the desired TDRSS contact times and begins an iterative process with the NCC in determining the contacts. Approximately one week before the target week the scheduler incorporates the NCC's TDRSS times into a preliminary resource schedule. The responsibilities of determining TDRSS contacts and incorporating them into the schedule may best be handled by one scheduler for multiple spacecraft. (Note: the P&S system will be flexible and able to support this. This study does not address how many hours per week/per spacecraft it takes to negotiate with NCC for TDRSS times). The expertise needed at this stage of the scheduling is more in knowledge of how to deal with the NCC and with the P&S software, than it is an expertise of the spacecraft and instrument specifics.

3.3.1.3 Final Scheduling

The final scheduling period runs from one week before the target week to approximately 2 days before the target day. The handling of changes between final scheduling and the target day require specific spacecraft commanding knowledge and therefore should be handled by a spacecraft commanding expert. Note: if any of the spacecraft have similar bus and commanding structures the spacecraft commanding expert could be the same person for those several spacecraft.

The 7 days prior to 2 days prior time period involves an interactive process where off-line engineers, with help from the schedulers, submit additional activities or deviations to baseline activities. Engineers and schedulers involved at this stage could be responsible for multiple instruments (either the same instrument on several spacecraft or multiple simple instruments), or for multiple spacecraft subsystems (most likely the same subsystem on multiple spacecraft, but the FOT could staff the responsibility of multiple subsystems on the same spacecraft to one person). The scope of responsibility for the engineering and scheduling staff will depend greatly on the complexity and stability of the spacecraft and instruments. The complexity factor for the AM-1 mission can be addressed now. We know that some of the instruments' BAP will rarely deviate, creating the opportunity for one scheduler to support multiple non-complex instruments. The stability factor is unknown and will remain unknown until post-launch. If all instruments and subsystems perform well and are fairly stable, staff can then have distributed responsibilities. However, an unreliable subsystem may need constant monitoring and attention, requiring specific staffing to handle that subsystem alone.

3.3.2 Multi-Mission Command Management Scenario

The command management scenario consists of one member of the FOT, 2 days prior to the target day, collecting input from several sources (detailed activity schedule from P&S, orbital data from the Flight Dynamics Facility [FDF], and infrequently as needed flight software updates from the science computing facilities [SCFs] and from the spacecraft contractor) and creating an integrated load and ground script for the target day using the CMS software. There are two points to annotate with regard to multi-mission staffing and CMS:

- 1) based on the simplicity and length of the task a member of the FOT could perform this function for several different spacecraft, and
- 2) this activity can take place concurrently for multiple spacecraft.

The CMS will have adequate security measures built into it to prohibit the FOT from combining input designated for different spacecraft. To that end, the CMS will ensure that: only authorized personnel are building loads; inputs to the process are spacecraft dependent, kept separate, and will not be mixed into a load for a different spacecraft; and the correct load will go to the correct spacecraft.

3.3.3 Multi-Mission Real Time Scenario

The real time scenario does address multi-mission staffing. The following is a summary of the key points of the scenario as it pertains to multi-mission staffing. Each real time contact needs a dedicated real time crew for the duration of the contact. This real time crew consists of an operations controller, command activity controller, spacecraft evaluator, and instrument evaluator. For a short period prior to and immediately following the contact a portion of this real time crew needs to perform some set-up and clean-up functions. With proper training and coordination within the EOC, it may be possible for a real time crew to handle contacts from different spacecraft (not simultaneously) during their shift. For example one crew may take a contact from spacecraft A, finish that contact, and then take a contact from spacecraft B, all from the same workstations by switching logical strings. A key to life-cycle cost reduction then depends upon the ability to reduce the likelihood of concurrent contacts via multi-mission scheduling (see section 3.4.4. for additional detail). If the number of concurrent contacts is kept to a minimum, the number of real time crews that must be staffed in the EOC at any given time is thus reduced.

3.3.4 Multi-Mission Spacecraft Analysis Scenario

The scenario depicts the evaluator and off-line engineers analyzing problems together. In the case of a non-time critical situation, they work with the schedulers to ensure the corrective action is incorporated into the detailed activity schedule. For time critical situations, they work with the command activity controller to ensure that the corrective action plan is executed during the next available real time contact. The architecture supports multi-mission staffing by providing access to data from multiple instruments and spacecraft at a single workstation to the off-line engineers (see the discussion in section 3.1). They will not have to log onto different workstations or re-initialize their current workstation to access data for different instruments and/or spacecrafts, thus alleviating the need to manually correlate data. The planned built-in flexibility of the system will allow quick and easy access to data and provides the flexibility necessary to support multi-mission staffing.

3.4 Multi-Mission Staffing Options

Section 3.3 discussed multi-mission staffing scenarios, explaining how tasks may be accomplished in a multi-mission based staff environment. Sections 3.4.X further the discussion by first addressing issues and concerns, then enumerating various instrument, spacecraft

subsystem and on-line staffing options. These options highlight "further study" areas from table 2-1.

3.4.1 Issues and Concerns

Initial AM-1 mission support will be staffed as mission-based, for the simple reason that it will be the only spacecraft that the FOT is supporting for more than a year. The exception to that is that an instrument engineer, will be monitoring several simple instruments simultaneously. This will continue up until the time of pre-launch support for the following 2 spacecraft (that are now scheduled to launch in the year 2000). It is recommended that most of the pre-launch, and all of the launch, in-orbit checkout and initial months of science and orbit maintenance for all additional spacecraft post AM-1 have dedicated, mission-based staffing. (Note that these recommendations are contingent upon further knowledge of the future spacecraft bus and instrument requirements). These are critical times in a spacecraft life cycle and need a dedicated staff to ensure that the mission is started correctly, that procedures are flushed out and modified properly, that systems are properly analyzed, and that this data is fed back into the databases, software and procedures.

Anomalous or degraded subsystem performance complicates operations, and complicates attempts to distribute staff and responsibilities. Once subsystems degrade, they may require dedicated staff to control. The variables of when subsystems will degrade and when other anomalous situations will occur make proposing reduced staffing levels before an operational period too risky. However the staffing is done, contingency staff will need to be in place to handle simultaneous anomaly situations.

3.4.2 Instrument Staffing Options

Many of the Instrument Evaluators in the EOC may have responsibility of multiple instruments. The exact number of instruments an evaluator will be accountable for will be a function of the complexity of the instruments and the stability of the instruments' operations. Possible options include:

- 1) combining the responsibility for the 2 CERES instruments on AM-1 and the 2 CERES instruments on PM-1,
- 2) combining the responsibility for the MODIS instrument on AM-1 and the instrument on PM-1, and
- 3) combining the responsibilities of instruments with similar operational scenarios.

The instrument evaluator staff is responsible for ensuring the correct execution of spacecraft commands during real-time contacts, loads included. They are also responsible for the detection of spacecraft and instrument anomalies via telemetry analysis. If an instrument evaluator detects an anomaly, they should execute all directions and procedures defined for that type of anomaly. Regardless of whether an anomaly has a defined response or not they will also execute an anomaly notification procedure that will notify the appropriate responsible off-line engineer and respective management personnel, and they will enter into immediate consultation about the anomaly and responses executed. Until the arrival of the appropriate personnel, they would

commence the collection of all pertinent data (telemetry and non-telemetry) for subsequent analysis. They could request that additional real-time support be scheduled to aid the anomaly analysis. The anomaly notifications procedure will list additional persons to contact in the event that the prime contact was not immediately located.

The above activities are to occur in support of a detected anomaly at all hours of the day or night, and in the case of multiple instrument anomalies. Anomaly response directions and procedures will be developed during pre-launch testing, In-Orbit Checkout (IOC), and science mission modes.

3.4.3 Spacecraft Subsystem Options

The expertise of the off-line staff (schedulers and off-line engineers) should be used across multiple missions when possible. For schedulers, much of the potential for distributing the responsibility will depend upon their work loads, which are dependent upon several factors: stability of the instruments and spacecrafts, complexity of the instruments, volatility of the instrument BAPs, and complexity of the necessary subsystem scheduling support. However, the P&S is planned to be flexible enough to allow the responsibilities to be distributed in whatever manner is determined optimal. Some examples include:

- 1) sharing scheduling support among same instruments,
- 2) sharing scheduling support among similar instruments,
- 3) one scheduler working the NCC interface for multiple spacecraft, and
- 4) a scheduler supporting the same subsystem scheduling on multiple spacecraft.

In a like manner, off-line subsystem expertise can be shared across missions. An expert in attitude control can provide this support for several spacecraft. A power subsystem engineer could analyze the solar arrays for multiple spacecraft. The spacecraft evaluator staff is responsible for ensuring the correct execution of spacecraft commands during real-time contacts, loads included. They are also responsible for the detection of spacecraft and instrument anomalies via telemetry analysis. If an spacecraft evaluator detects an anomaly, they should execute all directions and procedures defined for that type of anomaly. Regardless of whether an anomaly has a defined response or not they will also execute an anomaly notification procedure that will notify the appropriate responsible off-line engineer and respective management personnel, and they will enter into immediate consultation about the anomaly and responses executed. Until the arrival of the appropriate personnel, they would commence the collection of all pertinent data (telemetry and non-telemetry) for subsequent analysis. They could request that additional real-time support be scheduled to aid the anomaly analysis. The anomaly notifications procedure will list additional persons to contact in the event that the prime contact was not immediately located.

The above activities are to occur in support of a detected anomaly at all hours of the day or night, and in the case of multiple subsystem anomalies. Anomaly response directions and procedures will be developed during pre-launch testing, IOC, and science mission modes.

The ability to share this responsibility across missions is directly affected by the similarity of the spacecraft bus architecture and the stability of the subsystems. The more the spacecraft share similar characteristics, the more reuse of expertise will be possible.

Other factors affecting the off-line staffing in the EOC include the following:

- 1) the FOT over time will increase the proficiency in ground system and flight operations procedures,
- 2) as the AM-1 mission matures, additional efficiencies may be identified,
- 3) the EOC software/architecture reuse in support of next mission lessons FOT ground system learning curve and maintains FOT service reliability,
- 4) the subsequent EOS missions are less difficult and less laborious at mission start due to experience and knowledge gained from previous operations, and
- 5) on-line engineering staff can be promoted to off-line staff positions in support of existing spacecraft or new spacecraft, adding valuable real-time experience to the off-line staff.

3.4.4 On-Line Staffing Options

Table 3-1 shows a rough statistical analysis of the potential for having concurrent contacts in the EOC. The numbers represent the percent of the contacts that will run concurrently. For example, when two spacecraft are being controlled by the EOC, 35% of the time that the FOT is taking real time contacts, the contacts will overlap. Even if the 2000 X contact overlaps the AM-1 contact for only a portion of its 10 minute contact, that contact in its entirety is considered concurrent, since 2 unique real-time teams in the FOT would be needed to handle that situation.

Many assumptions were made to develop these numbers, to wit: the X spacecrafts are assumed to require 1 ten minute contact per 99 minute orbit, the AM-1 spacecraft is assumed to require 2 ten minute contacts per 99 minute orbit, and the Y spacecraft are assumed to require 6 ten minute contacts per day.

The bold numbers in the graph show the potential situations that, if the risks could be mitigated, could result in the reduction of real-time crews. (A real-time crew is considered to include the operations controller, command activity controller, spacecraft evaluator, and instrument evaluator(s)) For example, after 3 spacecraft are through their checkout period and into normal operations, 1.3% of the time that the EOC is in contact with the spacecrafts, all 3 spacecraft will be requesting contact with the EOC at the same time. If through analysis of these situations it can be determined that one of the contacts could be dropped without a loss of science data, the EOC could operate with only 2 real-time crews.

Table 3-1. Concurrent Contacts

year	spacecraft	number of s/c in concurrent contact				
		1	2	3	4	5
1998	AM-1	100				
2000	X	65	35			
2000	Y	55.7	43	1.3		
2002	X	35	51	10	.4	
2002	Y	20.85	62	12.5	4.5	.15

contacts:

AM-1 is 2 10 minute contacts for each 99 minute orbit

X is 1 10 minute contact for each 99 min orbit

Y is 6 10 minute contacts per day

A detailed study needs to be undertaken to examine this problem. First, the numbers in table 3-1 need to be verified. Note that these numbers have been determined from a strict statistical analysis. A detailed analysis may show the numbers to be reduced due to many factors, including:

- 1) simultaneous operations of TDRSS contacts are somewhat limited by the number of SSA antennas that TDRSS has in operation, and
- 2) the number of simultaneous contacts via ground stations may be limited by the spacing of EOS spacecraft in sun synchronous orbits so they are not simultaneously over the same ground station.¹

In addition, NCC scheduling needs to be factored into the analysis. Through placing constraints on the NCC to reduce the number of concurrent contacts (for AM-1 and the two X spacecrafts) the percent of concurrence should be reduced. Once that is determined, the affects of dropping a contact need to be studied, taking into account the recorder size onboard each spacecraft, the dump requirements of each spacecraft, the data rates of each spacecraft, the times until the next contacts, etc. These factors can all be combined to compute a risk factor to losing science data.

Other factors affecting the on-line staffing in the EOC include the following:

- 1) the FOT over time will increase the proficiency in ground system and flight operations procedures,
- 2) as the AM-1 mission matures, additional efficiencies may be identified,

¹ However, during handovers from one spacecraft in a series to the next, the two spacecraft will probably be in view of the same ground station at the same time.

- 3) the EOC software/architecture reuse in support of next mission lessons FOT ground system learning curve and maintains FOT service reliability, and
- 4) the subsequent EOS missions are less difficult and less laborious at mission start due to experience and knowledge gained from previous operations.

3.5 Transition of Staff

Experienced staff should be able to transition basic skills to new spacecraft easily. This is facilitated by several factors:

- 1) the reuse of the FOS architecture within the EOC to support the different spacecraft,
- 2) if implemented, the DSS can capture the knowledge of the experts before they transition, along with empirical data on historical operations, and
- 3) given the above 2 items, the FOT can possibly be backfilled by either less staff and/or less experienced staff.

In addition, the amount of ground system training the transitioning staff will require is reduced, since they already have the experience working within the EOC with the current architecture. Deterrents to the transitioning to new spacecraft include differences in spacecraft bus and new instrument requirements. The extent that these differences can be minimized affect inversely the ability to easily transition.

AM-1 will launch, complete its 'In-Orbit Checkout (IOC) and enter its' science phase of the mission. The FOT must then begin to support the next EOS mission. Members of the FOT will be selected for a launch support team. New FOT members will be hired and trained to fill each required AM-1 position. Launch teams will consist of a small number of FOT off-line engineers who will interface with the vehicle contractor. Jointly, they will specify and produce the operational procedures, tools, and data necessary to support EOC compatibility testing, the actual launch, and routine flight operations. The launch team and the vehicle contractor will perform the bulk of the launch and IOC activities. This team will also analyze the support requirements for the new spacecraft and determine the best way to integrate it into the existing EOC operations environment.

4. Findings

4.1 Potential Opportunities for Life Cycle Cost Reductions

Many potential opportunities exist for increased FOT efficiencies and reductions in life cycle costs. However, June 1994 is too early in the process to identify specific numbers or specific areas of reduction.

The FOS architecture does not preclude either multi-mission staffing or mission-based staffing. The architecture is flexible and can handle either setup with no additional hardware or software. This is a key finding. The planned built in flexibility of the EOC will allow the EOC manager to staff, and to shift staff, according to the current needs, problems and anomalous situations that arise.

The transition from the "old approach" to the proposed plans has afforded many opportunities for FOT efficiencies. Areas of further study exist that could lead to a reduction in lifecycle costs. Those include: technology insertion and operational concept evolution.

Key variables that will affect FOT flexibility and efficiencies are stability (of spacecraft, of spacecraft subsystems, and of instruments), similarity in spacecraft bus, similarity in instruments and instrument operations, and complexity of instruments. The more stable and predictable operations are, the less risk is assumed by the combining and transitioning of responsibilities within the EOC. The more spacecraft that are similar and employ similar spacecraft bus architecture, the more that expertise in the EOC can be spread across spacecraft. We know that some instruments on AM-1 are also planned for other spacecraft, which will help in the sharing of expert knowledge and responsibility. But, if different instruments can follow similar and or simple predictable operational procedures, that will also result in the sharing of expertise and responsibilities. The converse holds true for all of these statements. Increases in instability, dissimilar spacecraft and multiple unique instruments and instrument operations will complicate the task at hand and require more "hands on" dedicated staff to handle these challenges.

4.2 Multi-Mission Staffing vs. Mission-Based Staffing

A multi-mission staffing profile provides much potential for savings within the EOC. Since the flexibility of the architecture can support either staffing profile (multi-mission or mission based), it then becomes a matter of maximizing the efficiency of the personnel while keeping risk to an acceptable level. Also, many of the decisions cannot be made until the stability of the spacecraft and instruments have been determined to be sufficiently high. It is recommended that staffing for launch, spacecraft checkout and at least the first 6 months of operation are strictly mission-based. Some pre-launch activities could potentially be supported by other than a non-dedicated crew. Once this initial phase of operations is completed, depending on the stability of the various spacecraft subsystems, staffing decisions could then be made to combine responsibilities for maximum effectiveness of the FOT while assuming a minimum of risk.

This portion of the study will be revisited post AM-1 launch.

4.3 Technology Insertion

The ECS FOS and M&O teams are investigating existing technologies and prototypes, for incorporation into the EOC architecture. These technologies hold the promise of increasing long term FOT efficiencies by promoting repeatability in the spacecraft command and scheduling activities, reliability in the analysis of spacecraft subsystem performance, extensibility as mission operations or requirements change, and maintainability to allow tailoring of the systems for specific needs.

4.3.1 Old Approach to ECS Approach

These technology insertions are currently planned for the EOC, and represent an improvement over older, traditional control center approaches. Sections 4.3.1.x accentuate some of what is listed in table 2-1 under the column "ECS Approach".

4.3.1.1 Command Management Automation

The CMS, while only at the early system design phase, is heading toward the direction of automating many of its functions. If this design goal is reached, the amount of interaction the FOT will have with the CMS tools will be reduced, thus saving in FOT hours needed to produce integrated loads and ground scripts. The assumption reflected in the EOC Staff Positions (Appendix A) is that a sufficient level of automation will occur allowing that the functionality of interacting with the CMS can be subsumed by the scheduler position.

4.3.1.2 Ground Scripts

The EOC will incorporate software technology designed to automate and simplify many FOT responsibilities. A close look at the actions performed by the FOT personnel during a real-time contact shows that these actions are repeated from contact to contact, for each type of contact (passive analysis, data dump, command load). A feature of Loral heritage systems is the creation of a ground script by their respective CMSs, that encapsulates these actions into a time ordered schedule executed automatically during the real-time contact. This technology is designed to reduce the work load of the controllers, providing repeatability and reliability in the commanding of the spacecraft, since all routine commands are executed by the system. Ground scripts will aid the controllers in the support of anomalies by freeing them from routine responsibilities to concentrate on specific problems.

4.3.1.3 Other Current Plans

The prototype effoRTS on-going within the FOS has produced improvement ideas currently under investigation. One of those ideas is a concept called quick-analysis. Quick-analysis is a scheme that will allow the operator improved methods of accessing data. It provides, through several intuitive selection methods, the ability for the operator to view different groupings of real-time and near-real time data in a variety of formats. This flexibility should help the real-time crew in their investigation, identification and isolation of faults.

In addition, it is planned to provide access to context sensitive help and to all pertinent documentation on-line. This quick, indexed access to volumes of pertinent data will be a useful, timesaving tool for the FOT.

4.3.2 Further Study

These future study areas represent opportunities, along with multi-mission staffing, for increasing the efficiency of the FOT while at the same time decreasing life-cycle costs. Sections 4.3.2.x accentuate some of what is listed in table 2-1 under the column "Further Study".

4.3.2.1 Enhanced Decision Support System

Complex spacecraft require constant monitoring of many parameters to detect anomalous behavior. Traditional operational practices use human operators to scan telemetry, watching for deviations from expected performance. By developing an automated decision support system, much of the effort involved in fault detection, fault isolation, recovery, and control of the spacecraft may be reduced.

An enhanced Decision Support System (DSS) could improve the efficiency of the FOT by:

- lessening operators' need to analyze large volumes of data,
- providing advisement and information,
- evaluating the effects of proposed commands to the spacecraft,
- decreasing the response time to correct anomalies, and
- reducing the amount of experience lost through operator attrition by encoding their knowledge into the DSS.

4.3.2.2 Other Areas of Study

Other areas exist that need to be studied further. The impact on the FOT in terms of time commitments of analyzing back-orbit data more selectively should be examined to determine to what extent the FOT can be relieved of this manual, time intensive task to perform more in-depth analysis. Training should be studied. Does the amount of automation affect the training time, either increase or decrease? Does the availability of more sophisticated on-line documentation affect the FOT? Would the availability of a scheduling/resource allocation tool for the EOC manager be beneficial in dealing with a multi-mission staffing scenario. This tool would provide the EOC manager the capability to schedule and shift resources (man and machine) to handle situations as they arise in the control center.

In addition, code 520/code C has undertaken an RTOP to identify and demonstrate automation technology that can be applied to EOS to reduce operations cost. Specifically they will be investigating methods and feasibility of spacecraft pass automation. Also, the ECS contractor is continuing to survey and review control center technology, and in doing so has visited many different control centers (NASA, NOAA, Intelsat, DOD).

4.4 Evolving Operational Concepts

As the instrument manifest for the first spacecraft has evolved to include four simple and one complex instrument, the operational concepts for handling the scheduling of those instruments has also evolved. Some of the options are described in the multi-mission staffing discussed earlier. As we get closer to launch the operational concepts will converge, becoming more defined. As that occurs we may find additional opportunities for efficiencies in the FOT resulting from simplified concepts and procedures.

5. Operations Trade Study Process

The analysis of the EOS flight operations concept is a continuum that involves the coordinated efforts of the ECS Flight Operations Team and the Flight Operations Segment development staff throughout the project life cycle. In preparing the current version of the operations concept, this team has reviewed operations concepts for many other control centers. This distilled information is reflected in the changes from the "old approach" to the "ECS approach", as defined in Table 2-1. The team will continue to explore potential areas to enhance the operations concept through further study.

The process that the joint operations and development team uses to improve the system is outlined in Figure 5-1. In particular, the operations staff is involved in supporting the development team during all phases of development. This enables the user to influence the design and implementation of the system early in the process, which provides the best results. In addition, it ensures that the user perspective is included as an integral component in the design process. This includes providing input to the development of prototypes such as the Instrument Support Toolkit, Planning and Scheduling, Command Management, and Decision Support System.

In addition, the operations staff will be able to influence areas where routine, manual tasks can be automated to improve the FOT's efficiency. For instance, a display window could be developed that summarizes the state of all EOS spacecraft and identifies what each FOT member is currently doing. This information could be used by the Flight Operations Manager to quickly reassign a staff member to support investigation of an anomaly that has developed.

Due to the nature of the duration of ECS and the phasing of multiple spacecraft into operations over the next several years, lessons learned during operations of the EOS spacecraft will be able to be fed back into the development system that supports the subsequent EOS spacecraft. This pertains to improvements in supporting multiple spacecraft and instruments, as well as future technical advancements that enable automation to be used to replace routine, manual tasks.

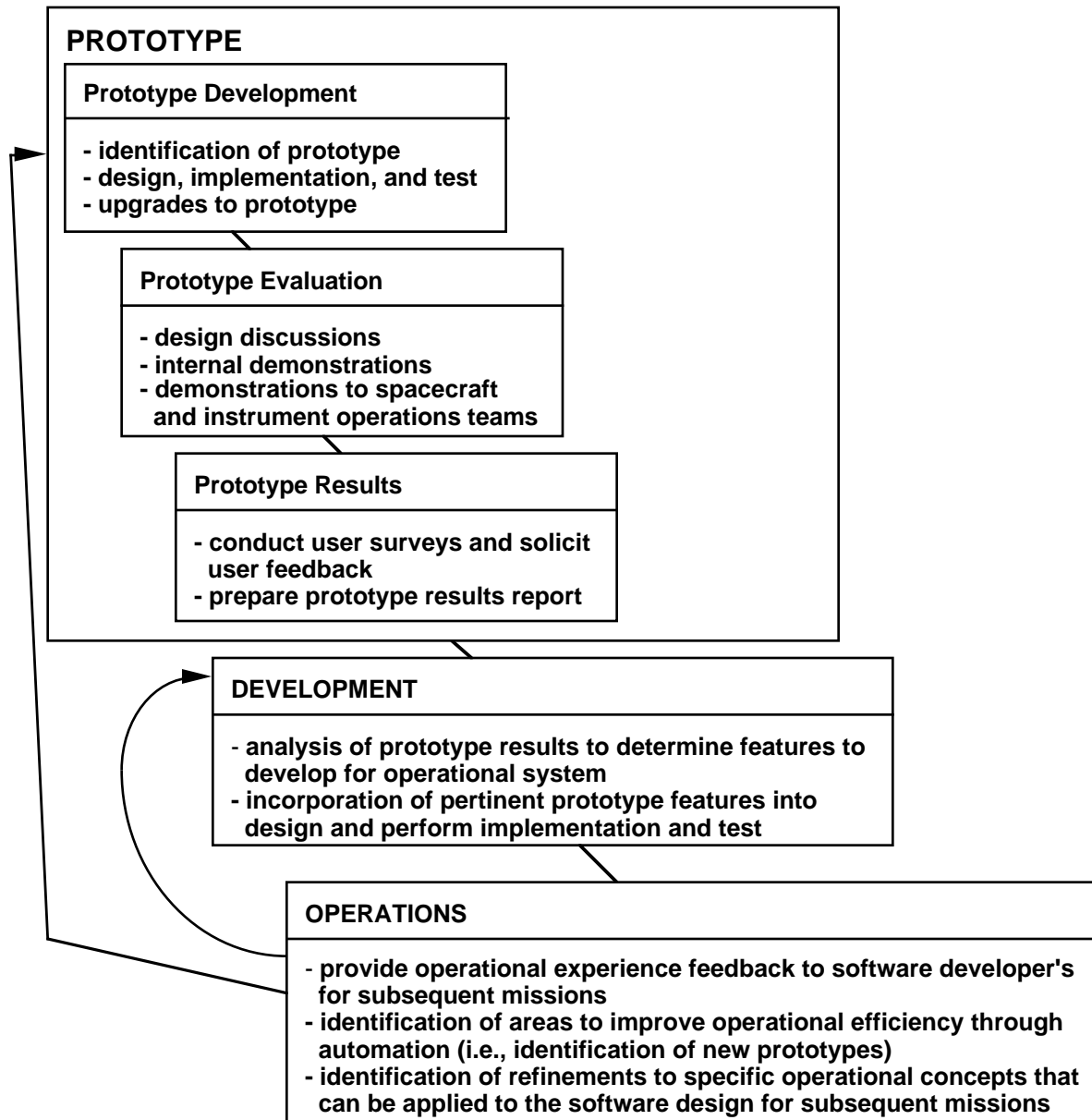


Figure 5-1. Joint Operations and Development Process

Appendix A. EOC Staff Positions

It should be noted that the ECS proposal took into account many of the subjects provided in this paper when establishing the FOT staffing levels. The EOC position descriptions fall into four categories: management, management support, off-line and on-line. The management positions are: EOC manager, Flight Segment Engineer, and Flight Operations Manager. The management support positions are: Training Coordinator, Administration, Configuration Management, Performance Assurance and Operations Coordinator. The off-line positions are Off-Line Engineer, Mission Planner/Scheduling Supervisor, and Scheduler. The on-line positions are: Operations Controller, Command Activity Controller, Spacecraft Evaluator, Instrument Evaluator, and Ground Controller. WBS-8 FOT sustaining engineering functions and staff positions are not addressed in this paper.

A.1 EOC Manager

The EOC manager has primary responsibility for the safe and consistent operation of the EOC, as well as the DADS operations at the GSFC Distributed Active Archive Center (DAAC). The EOC Manager has the overall responsibility for all EOC technical and management functions.

A.2 Training Coordinator

The training coordinator is responsible for the implementation of the training plan, insuring that the FOT is properly trained. The training coordination supports the EOC and the DADS operations at the GSFC DAAC.

A.3 Administration

This person is responsible for the administrative and secretarial duties for the FOT and for the DADS operations at the GSFC DAAC, and is responsive directly to the EOC manager.

A.4 Configuration Management

FOS Configuration Management has the responsibility of approving configuration management procedures with upper management, ensuring that changes to EOC hardware, software, and procedures are properly documented and coordinated, assists with the development and maintenance of the FOS library, coordinates Requests for Information Disposition (RID) requests generated during FOS M&O reviews, and generated monthly Configuration Control Board (CCB) reports.

A.5 Performance Assurance

The Performance Assurance (PA) support will be split between FOS and DADS operations support at the GSFC DAAC. PA will be responsible for assisting the EOC management in monitoring, reviewing, and providing input to FOS M&O generated documents and reviews. PA

is also responsible for monitoring and recording M&O requirements satisfaction during all M&O simulations and tests involving EOS spacecraft.

A.6 Flight Segment Engineer

The flight segment engineer (FSE) is responsible for the overall health and safety of the EOS spacecraft. The FSE provides direction to the off-line and on-line engineering staff, leads in the development of spacecraft command procedures, leads anomaly resolution teams, and is responsible for the integrity of the ECS databases.

A.7 Off-Line Engineer

The off-line engineer is responsible for the health and safety of one or more spacecraft subsystems and/or instruments. Responsibilities for the assigned subsystem(s) and/or instrument(s) include: routine operation and management, supporting command procedure development, generating and reviewing performance and trend analysis, supporting testing, and supporting anomaly resolution teams. It is assumed that a substantial part of the off-line engineering work for the instruments will be done at the ISTs by the PI/TL. Specific responsibilities can be negotiated on a per-instrument basis.

A.8 Mission Planner/Scheduling Supervisor

The mission planner/scheduling supervisor is responsible for the overall EOC scheduling activities and scheduling personnel. The mission planner/scheduling supervisor leads in the development of conflict resolution procedures, supports development of scheduling activities, provides direction to the EOC scheduling personnel, and is the point of contact for the project scientist when the project scientists need to make conflict resolution decisions.

A.9 Scheduler

The scheduler performs EOC spacecraft and instrument resource scheduling. The majority of this work is done during the day shift, and the staffing profiles will reflect this. Schedulers could be staffed during the second and third shift to handle TOOs, late changes, and IP-ICC support. The responsibilities of the scheduler include: generating long-term spacecraft operations plans based upon inputs from the off-line engineers, creating baseline activity profiles based upon PI/TL input and the LTIP, initial scheduling to establish NCC TDRSS contact times over a target week, final scheduling, conflict resolution, TOOs and late changes, feeding the final detailed activity schedule into CMS, and generating the integrated loads and the ground scripts using the CMS. The scheduler has responsibility for the scheduling of shared resources, including spacecraft platform subsystems such as attitude control, command and data handling, thermal and power, etc.

A.10 Flight Operations Manager

The flight operations manager is responsible for the daily EOC operations and mission support, and is responsible for the management of EOC resources. The flight operations manager

provides direction for the scheduling activities, working with the flight segment engineer and the operations coordinator to ensure smooth and safe EOC operations.

A.11 Operations Coordinator

The operations coordinator will assist the EOC management in the areas of configuration management, project database maintenance, EOC ground system anomalies, EOC software updates, that involves the FOS software development organization. The operations coordinator will schedule all ground system tests and simulations that involve EOS spacecraft.

A.12 Operations Controller (shift)

The operations controller is the lead position on shift, supervising all real-time spacecraft commanding and data capture activities. The operations controller is responsible for shift briefings and debriefings, interfaces to external and internal elements, coordinates real time scheduling changes, approves real time command uplink, leads anomaly resolution, monitors the activity timeline, maintains the shift log, generates management reports, and represents EOC management during non prime shifts.

A.13 Command Activity Controller (shift)

The command activity controller (CAC) is responsible for all real-time command initiation and verification. He supports all real-time data capture, is responsible for pre-contact ground system configuration, is responsible for post-contact data playback and archival, activating and monitoring the ground script, monitoring the performance data, assisting the spacecraft and instrument evaluators, and debriefs the operations controller.

A.14 Spacecraft Evaluator (shift)

The spacecraft evaluator performs the real-time spacecraft bus command and telemetry monitoring and analysis. The spacecraft evaluator is responsible for the spacecraft anomaly detection and contingency procedure execution, all routine spacecraft command load validation, provides technical support to the operations controller and command activity controller, and performs routine spacecraft performance and trend analysis.

A.15 Instrument Evaluator (shift)

The instrument evaluator performs the real-time instrument command and telemetry monitoring and analysis. The instrument evaluator is responsible for the instrument anomaly detection and contingency procedure execution, routine instrument command load validation, provides technical support to the operations controller and command activity controller, and performs routine instrument performance and trend analysis.

A.16 Ground Controller (shift)

The ground controller is responsible for EOC systems administration, data management, and for supporting engineering, configuration management and data entry tasks.

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Abbreviations and Acronyms

BAP	Baseline Activity Profile
CAC	Command Activity Controller
CCB	Configuration Control Board
CMS	Command Management Subsystem
DAAC	Distributed Active Archive Center
DAR	Data Acquisition Request
DSS	Decision Support System
ECS	EOSDIS Core System
EOC	ECS Operations Center
FDF	Flight Dynamics Facility
FOS	Flight Operations Segment
FOT	Flight Operations Team
FSE	Flight Segment Engineer
IST	Instrument Support Toolkit
IOC	In-Orbit Checkout
LTIP	Long Term Instrument Plan
LTSP	Long Term Science Plan
PA	Performance Assurance
P&S	Planning and Scheduling
PI/TL	Principle Investigator and/or Team Leader
RID	Request for Information Disposition
SCF	Science Computing Facility